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LITERATURE AND MINING

By J. C. Murray, B.A., B.Sc.*

The relation of literature to mining has always been unsatisfactory. Although the literary workers of the past and of the present owe much to mining, that debt has neither been paid nor recognized. The existence of this debt needs no proof. I need only mention one of the several devices whereby ingenious authors relieve impecunious heroes. The English novelist creates rich gold mines in vague Australia; the American novelist usually prefers the Western States. However, there appears to be a well-grounded belief in certain literary circles—manufacturing circles is a better phrase, for the average novel is truly a manufactured article—that mining is the only honorable means whereby a man can become suddenly rich without selling his soul. And there is some real basis of fact behind this. Hence it is that in the pages of modern fiction many scores of bronzed, bearded, brawny lovers have returned from Australian "diggings" to crush their usually anaemic betrothed in their yearning arms. So also mining endows many a deserving character in fiction with unhoped-for affluence. Usually both authors and readers can lay claim to a profound and absolute ignorance of everything pertaining to the industry. This seems to apply even to the few authors who have written novels that purport to be devoted to mining matters. I remember one novel, the scene of which was laid in the Coeur D'Alenes. The author was—perhaps is yet—a lady. She set herself calmly to work to disorganize the bowels of the earth. She controverted all the fundamentals of geology, and introduced radical changes in stamp-mill practice. I remember that the stamps of a 10-stamp mill were described as weighing hundreds of tons. This sufficiently shows the degree of accuracy that can be expected from the lay writer.

The time has come when better things can be hoped for. Ten or twenty years ago the mining engineer was regarded (and here I use a cheerfully contemptuous phrase coined by an Eng-

*Editor of the "Canadian Mining Journal," in an address to the Engineering Society.

lish professor occupying an important chair in one of our universities) as an "educated plumber." The phrase loses half its value when it is not pronounced in the ultra-English dialect with substitution of "ah" for "er," the last syllable.

Times have changed. Even at universities the mining engineer is looked upon as a more or less intelligent person. The public have begun to think well of him and to expect much of him. And gradually, through a series of reactions, the public are becoming better informed as to mining. Hence I believe the day will arrive when aspiring novelists will no longer dare to take undue liberties with the principles and practice of mining. Half a century ago, for instance, Mrs. Humphrey Ward could have misplaced North Bay with impunity. But to-day she is suffering for her lack of consideration. Similarly with mining. The author who can now perpetrate the grossest solecism about mining without suffering for it will be brought severely to book by the more critical reader of the future.

These generalities, however, are not what I intended to inflict upon you. With some indefinite intention of showing how much to interest him specially the mining man may find in general literature, I began to throw together a few notes. Lack of time and pressure of work have made it quite impossible for me to put these notes in coherent form. I must ask you to accept them as they are.

Perhaps in any library the department of travel will be found richest in allusions to mining. But many historical works contain much that interests the mining engineer, those of Parkman and Prescott, for instance, being liberally sprinkled with references to mining matters. Search for such references is hardly to be considered a worthy object in itself, but encountering them certainly adds zest to one's reading.

Lately I have been re-reading a few books that occupy places of honor in my small library.

The first book that I wish to glance over is the English translation of one of the greatest books of travel ever written—the "Travels of Marco Polo, the Venetian." I may refresh your memories by reminding you that Marco Polo was born in the year 1254. His father and his uncle were dauntless travelers. Together, they spent almost nine years in traveling between Venice and Cathay, where they visited the mighty Kubla Khan, whom Coleridge immortalized. A vivid imagination indeed would be required to picture the perils and hardships of that long journey into mysterious and unknown regions. It is no wonder that young Marco Polo's ambition was roused by the travelers' tales.

Marco's father and uncle returned to Venice in 1269. They had been commissioned by Kubla Khan to bring back with them 100 missionaries to operate upon the Cathaians. This they could not do without the permission of his Holiness the Pope. It hap-

pened that there was a papal interregnum, no successor to Clement IV. having been elected. After waiting for two years for the new Pope, Gregory X., to be elected, the Polos succeeded in getting two Dominicans. The hardships of travel very soon frightened these two worthies, and the three Polos—father, son, and uncle—started without them on their tremendous journey across Asia. Four years it took them to reach Shangtu, where Kubla Khan held court. Young Marco Polo immediately achieved popularity and rose in honor and wealth until he became one of the most important men in Kubla Khan's wide dominions. Not until the year 1295, after twenty-four years of absence, did the Polos see Venice again. The book that has come down to us was dictated to a Genoese scribe by Marco Polo during his imprisonment for a political offence, four years after his return. Cameras, note books and fountain pens were not current in those days. The traveler, therefore, had to trust to his memory. And it takes one's breath away to think that Marco Polo could remember details of his travels so accurately that much of his description holds good to-day.

We have to do, however, with Marco Polo's allusions to mining and kindred matters. It will not be necessary to go further into biographical details. Chapter IV. of Marco Polo's book opens with a reference to a "rich mine of silver," within a castle named Paipurth in Armenia Major, and closes with a paragraph on the Zorzaman (the Kingdom of Georgia) oil springs—the marvellously rich Baku oil field of to-day. "A fountain of oil," says Marco, "discharges so great a quantity as to furnish loading for many camels. The use made of it," he continues, "is not for the purpose of food, but as an unguent for the cure of cutaneous distempers in men and cattle, as well as other complaints; and it is also good for burning. In the neighboring country no other is used in their lamps, and people come from distant parts to procure it."

It is impressive to learn that the Baku gushers have been supplying the needs of a large population for many centuries. As I do not intend to introduce any statistics into this brief talk, I shall merely state that the Baku fields in Southern Russia are to-day of enormous commercial importance.

The extensive kingdom of Badakhshan, near the modern Afghanistan, is described by Polo as being rich in minerals. "In this country," he writes, "are found the precious stones called balaso rubies of fine quality and great value, so called from the name of the province. They are embedded in the high mountains, but are searched for only in one, named Sekinan. In this mountain the king causes mines to be worked in the same manner as for gold or silver, and through this channel alone they are obtained, no person daring, under pain or death, to make an excavation for the purpose, unless as a special favor, he obtains his majesty's license. Occasionally the king gives them as presents to strangers who pass through his dominion, as they

are not procurable by purchase from others and cannot be exported without his permission. "His object in these restrictions," as Polo quaintly expresses it, "is, that the rubies of his country . . . . . . should preserve their estimation and maintain their high price; for if they could be dug for indiscriminately . . . . . . so great is their abundance, that they would soon be of little value." It must comfort the spirit of that departed king to know that rubies are still embarrassingly precious. "There are mountains likewise in which are found veins of lapis lazuli . . . . the stone which yields the azure color, here the finest in the world. The mines of silver, copper and lead are likewise very productive."

As Marco Polo proceeded through each succeeding province or kingdom he made mental notes of its resources. In many cases, as in that quoted above, he dwells especially upon the minerals. Chalcedony, onyx and jasper are frequently mentioned, silver less frequently, but gold is often referred to.

Near the capital city Kain-du, in Eastern Tartary, the lake pearl fisheries attracted Polo. Here also the ruler restricted the search for these precious articles, for fear of glutting the market. This monopoly and close control of mining was characteristic of the times, and was given the color of wisdom by the very limited markets.

In consequence of the abundance of gold found in the rivers of the province of Karazan (the modern Chinese province of Yun-nan) gold was worth only six times as much as silver. Even then, there was a profitable business in exchanging silver for gold and vice versa in countries where the relative value of each metal was different. Five days' journey westward from Karazan lay the province of Kardandan. Here is an interesting excerpt:

"The currency of this country is gold by weight, and also the porcelain shells. An ounce of gold is exchanged for five ounces of silver . . . . there being no silver mines in this country, but much gold, and consequently the merchants who import silver obtain a large profit. Both the men and women," adds Polo, "have the custom of covering their teeth with thin plates of gold, fitted with great nicety." A form of vanity that survives to this day and generation.

Perhaps I have quoted enough to show that Marco Polo was consistently interested in the resources of mediaeval Asia.

I shall pass now to an author of a quite different type and of a later date—Mr. Samuel Pepys.

(*To be continued*)

ENGINE BALANCING

By J. M. Duncan, B.A.Sc.

An engine is said to be in perfect balance when the centre of gravity of its moving parts is a fixed point. As force is required to displace the centre of gravity of any system of bodies, another statement of this is that an engine is perfectly balanced when no resultant forces exist tending to move the engine framing bodily in any direction.

The forces generated by an unbalanced engine are commonly said to give rise to vibrations if the engine be in a boat, an automobile, or on any kind of elastic foundation; and to cause pounding or "nosing" if on a locomotive.

The amount of these vibratory or pounding forces is sometimes very large, and means must be sought to overcome them. On board ship the problem is most important—the discomfort of passengers, or, in a war vessel, the unsteadiness of the ship as a gun platform, being undesirable features, the result, as a rule, of unbalanced engines. With locomotives, as Mr. Macauley has pointed out,[1] the forces are often so great as to cause rail fracture, and must be very prejudicial to the machine itself.

Forces arise in engines through the centrifugal force of any unbalanced revolving parts, e.g., an unbalanced crank pin or connecting rod end. Centrifugal forces can always be balanced, however, by the use of counterweights, and are generally so balanced. But other forces than these arise in the reciprocating engine. Force is required to accelerate any body, and the reciprocating parts of an engine are continually being accelerated, for the velocity of the piston and attached weights is continually changing if the rotation of the crank pin is uniform. It might be said that this force comes from the steam in the cylinder. This is so, but a disturbance results nevertheless; for in Fig. 1 if A represents area of piston, and p represents cylinder head pressure of steam in pounds per square inch, then the total upward pressure tending to lift the cylinder from the columns is $p \times A$ lbs. The total pressure on the piston in a downward direction is likewise $p \times A$, but of this total pressure a part $p_1 \times A$ is absorbed in giving acceleration to the piston, crosshead and part of the connecting-rod while the remainder, or $p_2 \times A$, is transmitted through the rods and crank to the main bearings; $p_2 \times A$ is then the only downward force which opposes $p \times A$ in the upward sense; that is, there is an unbalanced force of $-p_1 \times A$ tending to raise the engine from its foundations; and a similar downward force will exist during the upward stroke.[2]

To ascertain the amount of this force, we must find an expression for the acceleration of the reciprocating weights. The expression is obtained by setting down an equation representing the position of the crosshead E (Fig. 2) in terms of θ, l and r, the latter two

1 "Locomotives, Steam vs. Electric." R. V. Macauley, B.A.Sc. in "Applied Science," Vol. VI. No. 4. p. 145.

2 Bauer and Robertson---"Marine Engines and Boilers," pp. 82---105.

being conveniently combined in the symbol $a = \frac{r}{l}$. This equation being differentiated once with regard to time gives the velocity of E and twice with regard to time gives the acceleration of E. The result is brought into the form of a series as below, for convenience of treatment — (α = acceleration of E).

$$\begin{aligned} \frac{\alpha}{r\omega^2} = {} & \mathrm{Ccs}\ \theta \\ & + \mathrm{Cos}\ 2\theta\ \left(a + \frac{1}{4}a^3 + \ldots\right) \\ & - \mathrm{Cos}\ 4\theta\ \left(\frac{1}{4}a^3 + \frac{3}{16}a^5 + \ldots\right) \\ & + \mathrm{Cos}\ 6\theta\ \left(\frac{9}{128}a^5 + \ldots\right), \text{ etc., etc.} \end{aligned}$$

That is, the piston has harmonic motion, harmonics of the first and all even periods being present. If the engine be in a ship it is

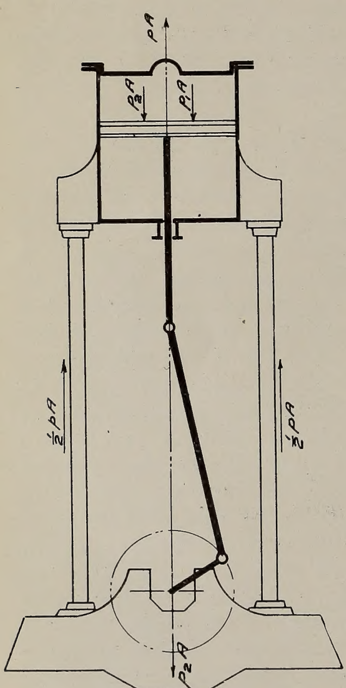


Fig. 1

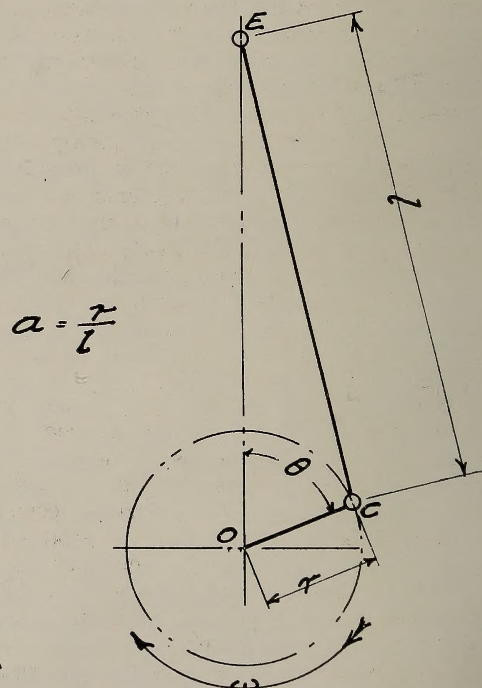


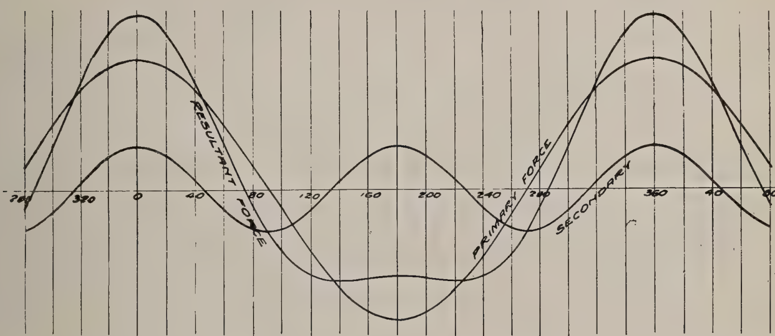
Fig. 2

most favorably located for making these harmonics evident to the senses, for the elastic structure of the ship can respond theoretically at least to vibratory impulses of any period; and vibrations of the sixth period actually have been found in a ship. Vibrations of higher periods than the second, however, are so small as to be quite

negligible in practice, and hence it is usual to speak of an engine as being "completely balanced" if it is balanced for the first and second periods, that is if no free forces or couples exist having positive "maxima" either once or twice during a revolution. (See Fig. 3) Thus we reduce the expression for α to the following :

$$\frac{\alpha}{r\omega^2} = \text{Cos } \theta + \text{Cos } 2\ \theta \left(a + \frac{1}{4} a^3 + \ldots\right),$$

and evidently for values of $a = \frac{1}{3.5}$ or $< \frac{1}{3.5}$ the following



CURVES REPRESENT FORCES DUE TO AN UNBALANCED RECIPROCATING WEIGHT. SECONDARY FORCES ARE HERE FOR A RATIO $a = \frac{r}{l} = \frac{1}{3}$

Fig. 3

approximation is sufficiently close — where the maximum error involved is 1%.

$$\frac{\alpha}{r\omega^2} = \text{Cos } \theta + a \text{ Cos } 2\ \theta$$

or $\alpha = r\omega^2$ (Cos $\theta + a$ Cos 2θ).

Now, $force = \dfrac{acceleration \times mass}{g}$

so $f = \dfrac{mr\omega^2}{g}$ (Cos $\theta + a$ Cos $2\ \theta$) if f = force due to acceleration of mass "m".

Symbols used throughout this article—

m = total mass of reciprocating weights actuated by one crank.
M = total mass of revolving weights actuated by one crank.
f = force generated by m.
F = force generated by M.
ω = angular velocity of crank (assumed constant, since if the centre of gravity is a fixed point for one speed it is a fixed point for all speeds).
α = acceleration of any part (either radial for revolving, or linear for reciprocating points).
r = length of crank.
l = length of connecting rod. $a = \frac{r}{l}$
θ = angle turned through by the crank from any reference direction.

We have thus a formula for the force due to the piston and all rigid attachments. The effect of the connecting-rod has also been determined by various investigators, and it has been found capable of very simple treatment. In Fig. 4, G is the centre of gravity of

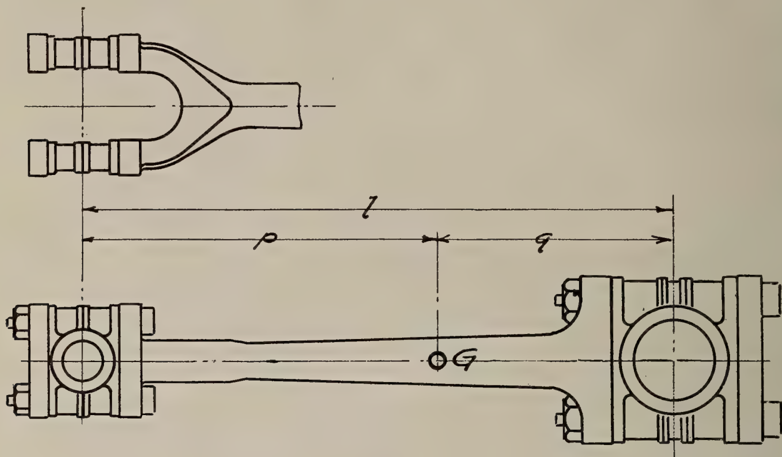


Fig. 4

the rod and m_c the mass. Then the net effect of the connecting-rod mass, m_c, is that a mass, $m_1 = m_c \frac{q}{l}$, may be imagined concentrated at the crosshead and the remainder, or a mass, $m_2 = m_c \frac{p}{l}$ at the crankpin. Thus m_1 may be included in m, the total recipro-

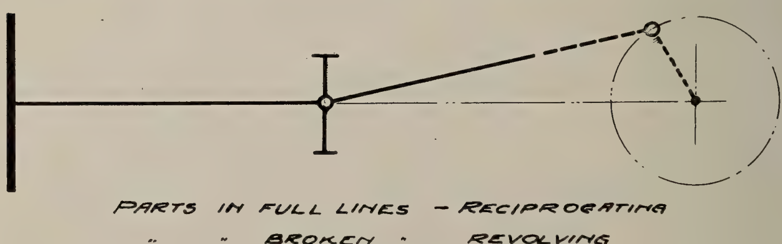


Fig. 5

cating masses, and m_2 in M the total revolving masses. The usual approximation for marine type rods is $q = 0.4l$. Fig. 5 shows diagrammatically the classification of weights now obtained.

It remains now only to set down the formula for the force F, due to the centrifugal effect of the revolving weights, a force which tends to move the engine framing, hence a distributing force in the balance of the engine. The expression is obtained here also

from the acceleration of the masses involved, and $F = \frac{Mr\omega^2}{g}$, since $a = r\omega^2$, for uniformly rotating weights.

Dalby's Graphical Representation of Formulæ

Rewriting the expression $\frac{mr\omega^2}{g}$ (Cos θ + a Cos 2 θ) thus

$$-\frac{mr\omega^2}{g} \text{ Cos } \theta \qquad (1),$$

$$+\frac{mr\omega^2}{g} a \text{ Cos } 2\theta \qquad (2),$$

the first is the projection on the line of stroke of centrifugal force $\frac{r\omega^2}{g}$ m due to the mass m moved by the crank OA (Fig. 6), r units long, which has moved with an angular velocity ω through the angle θ from the line of stroke. It then may be represented by a

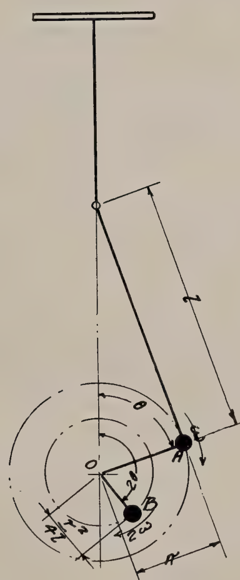


Fig. 6

vector parallel to OA. The sense adopted is O to A, positive, and the magnitude is the force $\frac{mr}{g}$ ω^2 *Cos* θ, to any chosen scale.

The second part of the expression may be rewritten thus—

$$\frac{mr\omega^2.}{g} a. \; Cos \; 2\theta = \frac{mr\omega^2.}{g} \frac{r}{l}. \; Cos \; 2\theta = \frac{m\,(2\omega)^2}{g} . \frac{r^2}{4l} \; Cos \; 2\theta.$$

This is the projection on the line of stroke of a force due to m actuated

by a crank $\frac{r^2}{4l}$ units long, which has moved with an angular velocity 2ω through the angle 2θ from the line of stroke. The vector is drawn as directed for OA. Fig. 6 shows also that a primary crank and a secondary crank may be imagined, the latter being $\frac{r^2}{4l}$ long, concentric with the former and revolving twice as fast.

Here it is well to note the effect of dcubling ω. Primary forces are quadrupled, their period halved; secondary forces quadrupled,

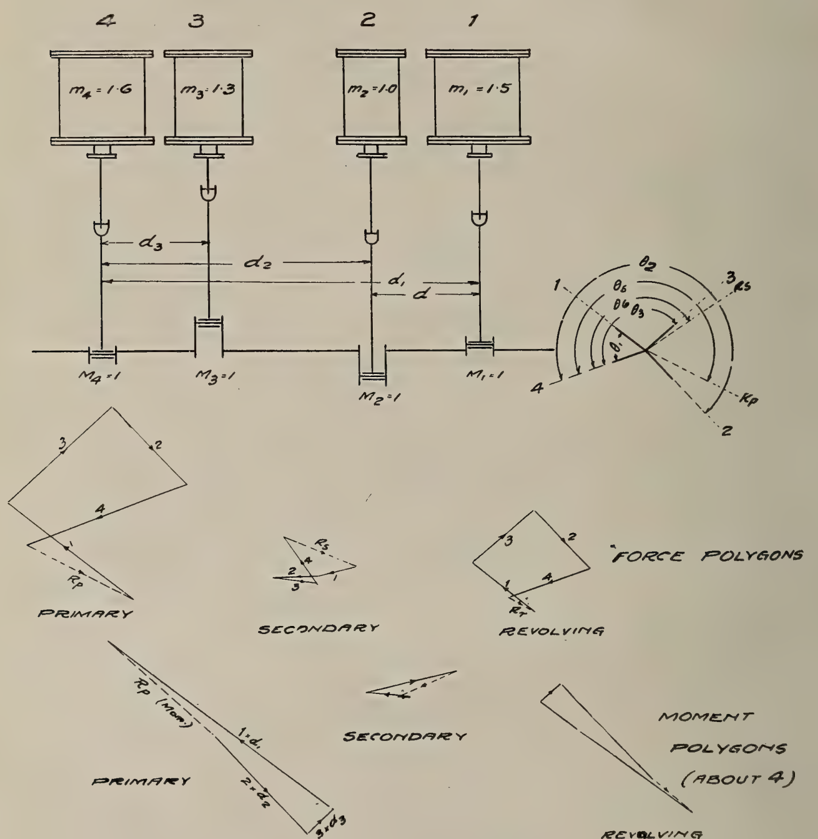


Fig. 7

their period quartered. Hence an increase of speed means a proportional increase of forces of all periods; but the higher periods rapidly become so short that the engine mass as a whole can not respond to them. The stresses are, however, increasingly serious, and at the same time very rapidly alternating.

To resume—if we have several cranks, as in Fig. 7, we may

find the resultant force in the engine by means of vector polygons. The resultant of the vectors drawn — the closing line of the polygon —will represent the free or unbalanced force in the engine due to the arrangement of weights, crank angles and cylinder spacing shown. This resultant means that the engine would be balanced for primary force by a reciprocating mass, equal to m_{R_p}, driven by a crank at an angle θ_5 from the reference line, which latter may always be chosen coincident with any of the cranks since the length of the resultant is unaffected by its position. Here the reference crank is crank No. 4. Secondary balance could be secured by the addition of a crank which would cause the secondary force f_{R_s} and whose crank angle would be θ_6 as shown. Revolving force polygons will be drawn in the same manner as the primary polygons above, but, while they may look similar it must always be remembered that revolving and reciprocating balance diagrams represent essentially different kinds of forces. (See pp. 220 ff.).

Note that in all expressions for forces and moments the factor $r\omega^2$ is present. We therefore, in drawing polygons may make the sides proportional to weights $\frac{m}{g}$ only. Then the resultant force f_{R_p} is $f_{R_p} = m_{R_p} \frac{r}{g} \omega^2 (Cos\ \theta + a\ Cos\ 2\theta)$ where $\frac{m_{R_p}}{g}$ is the resultant weight.

Forces and Moments

In a single crank engine neglecting the valve weights, forces are developed only in one plane—viz., that in which the crank pin rotates and containing the cylinder axis.

If there be two cranks, forces will be generated in two planes. If the cranks are not parallel a moment will exist $= f_2 \times d$ for reciprocating and $F_2 \times d$ for revolving weights if moments are about No. 1 (See Fig. 7), considering at present only cranks 1 and 2. The position of the reference plane will effect the amount of the moment if the forces are not balanced, but if the forces are balanced a free couple may exist. This, of course, is independent of the position of the reference plane. Since it acts in the plane of the cylinder and draft axis, this couple will have the tendency to tilt the engine bodily in this plane; hence has been termed by Inglis[1] a "tilting couple." Individual forces have no such tendency and are termed "hammering forces." Evidently a couple is a disturbing element and no engine is balanced in which a free couple exists.

Then in all multi-crank engines (including single-cylinder engines if the valve weights are considerable) for complete reciprocating balance the Primary and Secondary force and moment polygons must all close, and for revolving balance the force and moment polygons must likewise close.

1. John A. Inglis, "Balancing the Four-Crank Marine Engine," *Engineering*, June, 1911.

Reciprocating and Revolving Balance

Consider the nature of the forces f and F.

$$f = m \frac{r\omega^2}{g} (Cos\ \theta + a\ Cos\ 2\theta) \qquad (1)$$

$$F = M \frac{r}{g} \omega^2 \qquad (2)$$

Here f, due to reciprocating weights is constant in direction always having the cylinder axis as its line of action, but varies with Cos θ and Cos 2θ in amount; whereas F, due to revolving weights is constant in amount and variable in direction, always having the centre line of the crank for its line of action. Consequently revolving weights can not balance reciprocating weights, and vice versa.

To illustrate, suppose we re-write, (2),

$F = M \frac{r}{g} \omega^2\ Cos\ \theta + M \frac{r}{g} \omega^2\ Sin\ \theta$ (vectorially), or if M be here a counterweight fitted 180° ahead of (i. e., opposite to) the crank, $F = M \frac{r}{g} \omega^2 \left\{ Cos\ (\theta + 180) + Sin\ (\theta + 180) \right\}$

$$-M \frac{r}{g} \omega^2 (Cos\ \theta + Sin\ \theta).$$

Considering only counterweights and reciprocating weights we shall have $f + F = \frac{mr\omega^2}{g} (Cos\ \theta + a\ Cos\ 2\theta)$

$$- \frac{Mr\omega^2}{g} (Cos\ \theta + Sin\ \theta)$$

and if $M = m$.

$$f + F = \frac{mr\omega^2}{g} a\ Cos\ 2\ \theta - \frac{mr\omega^2}{g} sin\ \theta$$

$$f + F = \frac{mr\omega^2}{g} (-Sin\ \theta + Cos\ 2\ \theta),$$

which indicates merely a shift in phase of the primary reciprocating part of the force f; that is, if the engine be a vertical one, reciprocating forces are now acting horizontally, instead of vertically, as before. In a ship horizontal vibrations are usually of less amplitude for the same force than vertical vibrations. Therefore when nothing else can be done (as, for instance where an existing multi-cylinder engine is out of balance) it may be advisable to fit such weights. (See Bauer & Robertson, "Marine Engines and Boilers," pp. 92-100.) Note, however, that for a horizontal engine the fitting of such a counterweight would be the worst possible thing to do. Forces which formerly exerted a shear on the foundation bolts now produce a pounding on the foundation, or in the case of a locomotive, rail pounding which would be positively ruinous.

There is a possible compromise in the fitting of revolving counterweights—

If $M = \frac{m}{2}$, we shall have

$$f + F = \frac{mr\omega^2}{g} Cos\ \theta - \tfrac{1}{2}\frac{mr\omega^2}{g} Cos\ \theta$$
$$-\tfrac{1}{2}\frac{mr\omega^2}{g} Sin\ \theta + \frac{mr\omega^2}{g}.\ a\ .\ Cos\ 2\ \theta$$
$$= \tfrac{1}{2}\frac{mr\omega^2}{g} Cos\ \theta - \tfrac{1}{2}\frac{mr\omega^2}{g}.\ \ Sin\ \theta$$
$$+ \frac{mr\omega^2}{g}\ a\ Cos\ 2\ \theta$$

The effect of such a counterweight is the reduction of the *primary* reciprocating forces by ½, incidentally causing the combined primary forces to act as though caused by a mass $\frac{m}{2}$ revolving in the direction opposite to the crank. Secondary forces are seen to remain as before. The practical difficulty of fitting large revolving weights however, make it generally impossible to do more than balance the revolving weights alone and even this is difficult with the single cylinder engine.

Balancing Possibilities of Various Types of Engines

(1) The Single Crank Engine

(a) Centre Crank Type.—The best balance practically attainable is revolving balance only as noted above. The counterweights will be conveniently incorporated in the crank disc and it will generally be found difficult to put in enough weight to balance completely revolving forces.

(b) Side Crank Type—If revolving forces are balanced, a revolving couple will be introduced due to the overhang of the crank pin.

(2) The Two Crank Engine

(a) Two Centre Cranks.—Revolving balance is now easier to obtain. With the usual arrangement of cranks at 90° (for the steam engine) less total addition of weight need be added than for two independent single crank engines. Fig. 8 shows that if

M' = mass of total revolving counterweight

M = revolving mass for 1 crank, then $M' = M\sqrt{2}$. The saving in weight, $\frac{M}{g}(2 - \sqrt{2})$, is obtained by sacrificing perfect balance of moments but is well worth while. Fig. 9, illustrating a small compound engine built by the Collingwood Shipbuilding Company, shows how difficult it would be to put any more weight in this marine engine where the pinch wheel, which is used as a counterweight, has to clear the deck. Two balance wheels are used and they are placed as far apart as possible.

With the cranks at 90°, primary reciprocating balance is impossible; secondary forces are balanced, however, if the weights are equal. If the cranks are at 180°, primary forces are balanced

and a primary couple and secondary force and couple unbalanced. If with this arrangement, the cylinders are on opposite sides of the shaft, as in the small double-opposed gasoline engine, forces of all periods are balanced, as any force developed on the one crank is offset by an equal force acting in the opposite sense on the other.

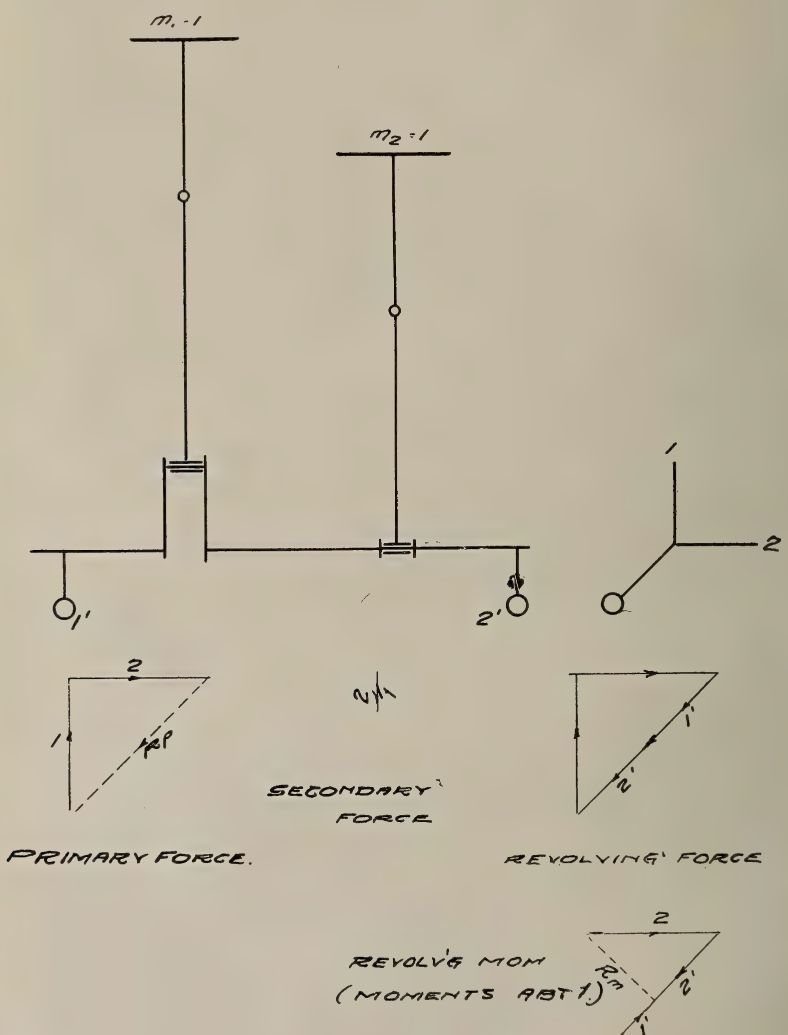


Fig. 8

A couple will be the only disturbance, and to eliminate this would require a split connecting-rod, enabling the two cylinders to be brought in line.

(b) Two Side Cranks.—The most important example is the

outside cylinder locomotive. Cranks are here at 90°. Revolving forces can be balanced by counterweighting each wheel opposite the crank pins but a small resultant moment still exists. This cannot be avoided unless cranks are differently arranged. Undoubtedly, however, hammering forces are much more serious than this small couple, which might here be called a "nosing couple" as it tends to produce "nosing" of the engine. But this couple will be so small compared to that produced by the reciprocating forces as to be negligible. Evidently reciprocating forces are horizontal in their direction, hence can not cause rail pounding; but since couples

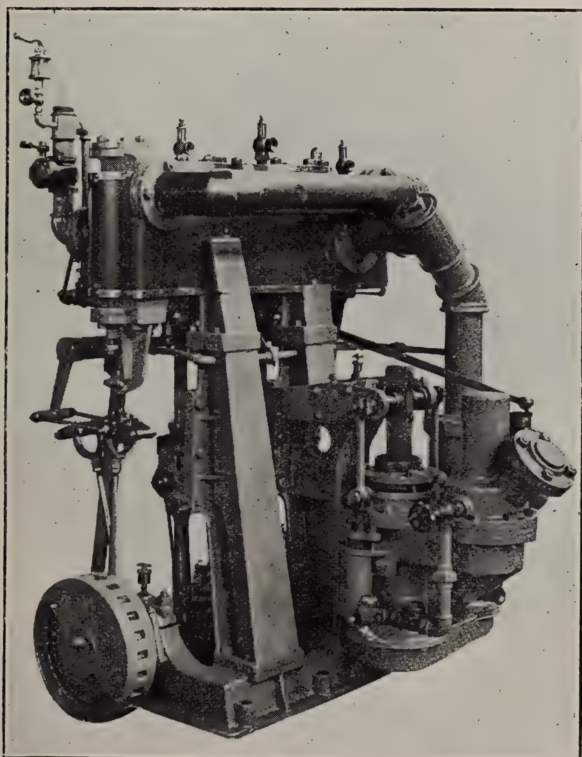


Fig. 9

can not be balanced, "nosing" will result, the couples tending to sway the front of the locomotive from side to side. There will be a "natural period" for this swaying and when the period of any of the couples coincides with this natural period the nosing will be a maximum. Thus, at some speeds it will be unnoticeable, while at a lower speed possibly excessive.

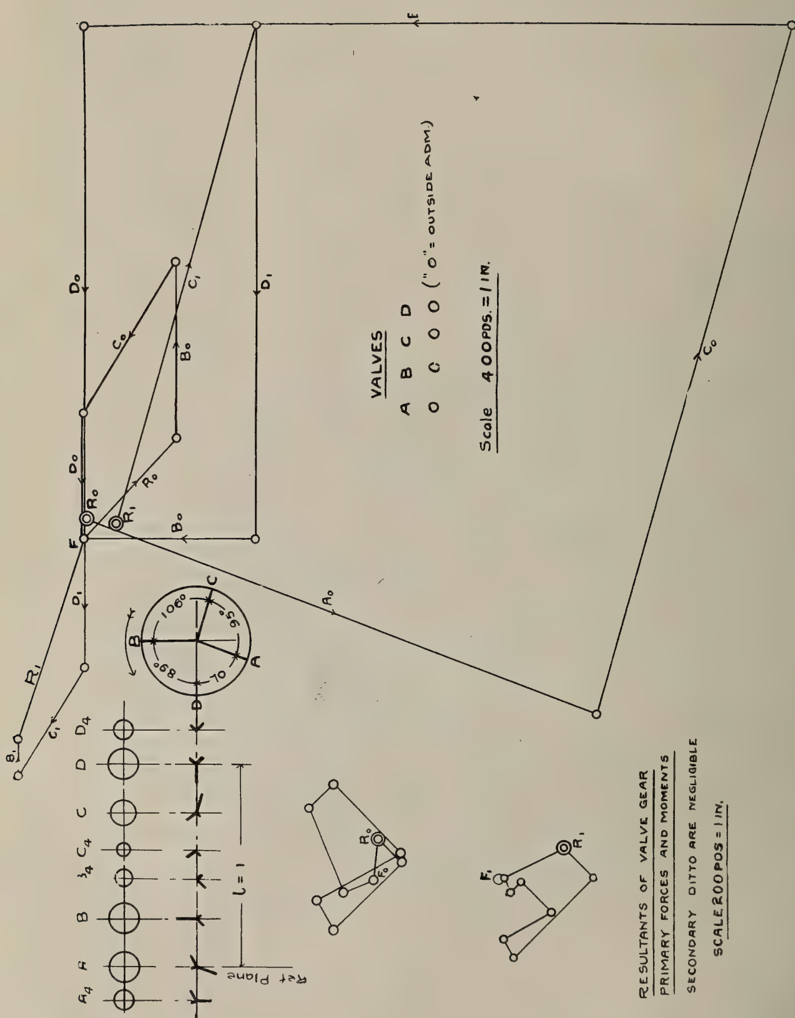

VALVES
A B C D
O C O O ("O" = OUTSIDE ADM.)
Scale 400 PDS. = 1 IN.
RESULTANTS OF VALVE GEAR
PRIMARY FORCES AND MOMENTS
SECONDARY DITTO ARE NEGLIGIBLE
SCALE 200 PDS = 1 IN.
Ref Plane
L = 1

Fig. 10

PRIMARY

	Cylinder Arms	Weights	Moments	Valve Arms	Weights		Moments	
		0	1		Ahead	Astern	Ahead	Astern
A	0	1130	0	—0.183	95	35	— 17	— 6
B	0.242	1460	354	+0.439	100	36	+ 44	+16
C	0.716	1495	1079	+0.574	100	36	+ 57	+21
D	1.000	1063	1065	+1.183	100	36	+118	+43

SECONDARY

	Cylinder Arms	Weights	Moments	Valve Arms	Weights		Moments	
		0	1		Ahead	Astern	Ahead	Astern
A	0.	283	0	—0.183	4	1	0	0
B	0.242	365	78	+0.439	4	1	2	—
C	0.716	367	262	+0.574	4	1	2	—
D	1.000	266	266	+1.183	4	1	5	1

(3) Three Crank Engines

(3) Three Crank Engines.—Only two arrangements of cranks are attempted with this engine—the usual being cranks at 120° the less common having the centre crank 180° from the other two. If the latter arrangement is adopted for balancing considerations, the centre crank weights are twice as heavy as on each of the outer cranks; then primary forces and moments are balanced. This arrangement with the double-acting steam engine has the disadvantage of a poor turning moment; with single acting gas engines it would be difficult to sufficiently increase the centre weights. The turning moment of the double acting engine with cranks at 120° is very good and balance is secured for forces of every period but the sixth and multiples of the 6th, if the three cranks have equal weights, as may be seen by inspection of the complete formula on page 214.

For example, where $\theta = 120°$; $2\,\theta = 240°$, and $4\,\theta = 480°$ equivalent to 120°. But $6\,\theta = 720°$ and corresponds to 0°, and the three sixth-period cranks coincide; polygons for all other periods are equilateral triangles.

Equal reciprocating weights are secured by thickening the piston of the high pressure and intermediate pressure cylinders in a triple-expansion engine; or, if the air pump be lever driven from the low pressure crosshead, thus virtually reducing the reciprocating L. P. weights, usually the M. P. becomes the heaviest weight and the H. P. need be increased very little. Revolving balance of forces is generally all that is attempted, as this can very conveniently be obtained by loading the pinch wheel. It will result in a constant unbalanced revolving couple, but, as reciprocating couples are unbalanced, this is usually neglected. To extinguish it would require counter-weights added in two planes.

Of perhaps not more than a theoretical interest is a three crank engine with two of the cranks on one side and a centre crank with weights equal to the sum of the other two, but "opposed," *ie*, on the opposite side of the shaft. This is merely a development of the double-opposed engine; couples are avoided and consequently the engine has absolutely perfect balance.

(4) Four Crank Engines.—Every additional crank in the engine means one more side to all vector polygons, and consequently greater balancing possibilities. With four cranks we have four-sided force polygons and three-sided moment polygons. We are now at liberty to change the crank angles as we please, and still, by changing also the weights, have both the poise and moment polygons of the first period close. Thus it will be possible to close a third polygon at the same time, i. e., to balance secondary forces as well.

It would not be permissible to modify crank angles if the turning moment were thereby made very uneven, but it has been proved that the angles which give the best balance for a four crank engine give also the best turning moment. Four cylinder locomotives are sometimes adopted on account of the superior balance possible, and marine engines for passenger boats are generally of the four crank type for the same reason. Fig. 10 shows a marine engine balanced for primary and secondary forces and primary moments, the method followed being described in detail.

(5) Five-Crank Engines.—Imagine two similar three-crank engines placed on the same bed plate in a manner such that their constant unbalanced couples oppose one another. Then, since forces in each are balanced completely (see p. 225) and the couples are equal and opposite, the engine is completely balanced. If now the two engines are made to approach one another till the centre cylinders coincide, the balance will be as before. Thus we obtain a five-crank engine completely balanced for all forces and couples except those of the sixth, twelfth, etc., periods. Fig. 11 illustrates a completely balanced five-cylinder engine. It will be

noticed that weights do not have to be equal as in the three-crank type.

We have now reached a type of engine with practically perfect balance. If more cranks are used, the balance can hardly be improved. In fact it is seldom that more than four cranks are used as the balance obtainable with them is quite good enough for all practical purposes.

Effect of the Valve Gear of an Engine

Since the valve gear of a steam engine is actuated by cranks in the form of eccentrics, it may be treated exactly as the main weights. The connecting rod ratio for the eccentric is so small, however, as to render secondary forces quite negligible.

As the valve gear weights are relatively small compared with the main weights, a common procedure is to treat them as purely

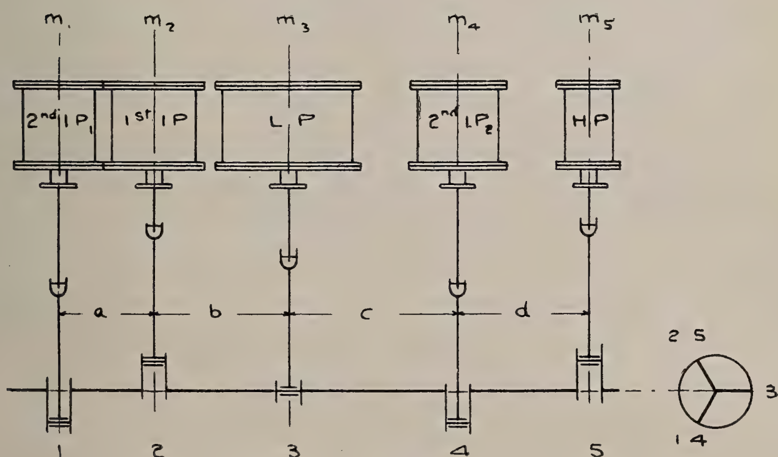


Fig. 11

revolving weights to be balanced together with the main revolving weights. This is a simple method and does not cause any large error in the balance of the engine; but an engine so balanced will generally have considerably more extra weight in the reciprocating parts than would be the case if the force and moment polygons included sides representing the valve gear as well as main weights. The advantage of the latter method is illustrated in Fig. 12. The Yarrow-Schlick-Tweedy System is to treat the valve gear weights separately as first mentioned above; then a spacing of cylinders and ratios of crank angles and weights which are symmetrical, are found to give the desired balance. By including sides representing the valve gears in the main weight polygons this symmetry is lost, but the saving in weight may be considerable. Accurate balance of a four-crank engine by the latter method is obtained by manipu-

lating the force and moment polygons for several trial values of the variables involved, viz., crank angles, weights and cylinder spacing,—a trial and error method. The elimination of the valve gear from the problem, however, makes it possible to arrive directly at the proper values to give the required balance. The objection to the method is the unnecessary addition of weight involved. The Taylor and Inglis diagrams are very useful in preliminary investigation. Nothing final, however, is accomplished, the force and moment polygons must still be manipulated and the best values of the unknowns found by trial and error.

Balancing a Four-Crank Marine Engine

We first estimate and tabulate the weights of all moving parts of the engine so far as at present designed. Any simple system of symbols such as used on the diagram (Fig. 10) will be of service.

To take an example, let the engine be of the 4-cylinder triple expansion type, the valves being all outside admission and driven by

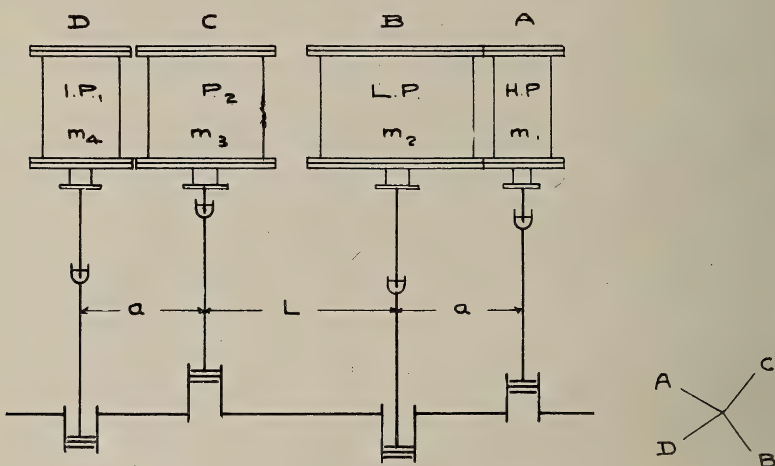


Fig. 12

Stephenson link motion. The connecting rod is four times the length of the cranks, that is, $a = \frac{r}{l} = \frac{1}{4}$. Note that an inside admission valve is actuated by an eccentric 90° ahead of that which operates a valve with outside admission. It is always well to show diagrammatically the positions of the various eccentrics and cranks as in Fig. 10. There are no auxiliaries driven from this engine. The heaviest piston will be the one whose weight will be unchanged throughout the problem, so it may be at once designed; for our engine it will be the I. P. piston. Thus, we have to estimate the weights of the I. P. piston, and all crossheads, connecting rods, piston rods, cranks and valve gear.

Estimating the Valve Gear

(The following is extracted from Taylor's paper).

Since these weights are included in the main polygons, they must be reduced by virtual weights having the travel of the piston for reciprocating weights and revolving with the crank for revolving

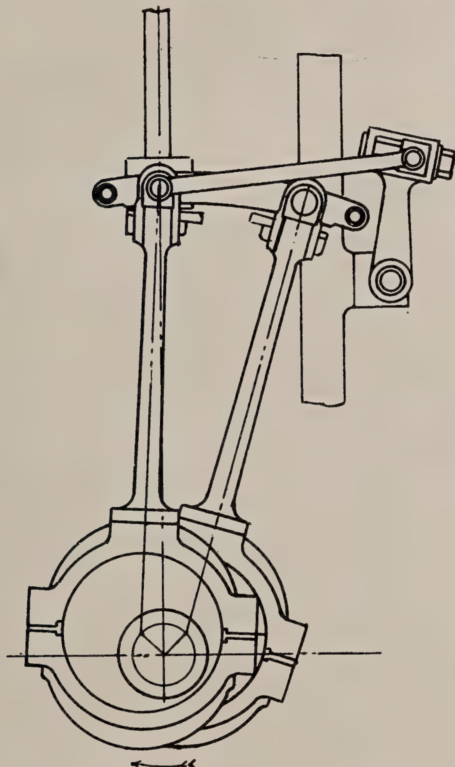


Fig. 13

weights. These virtual weights are obtained very simply by multiplying by the ratio

$$\frac{\text{Travel of Valve}}{\text{Stroke of Piston}}$$

Fig. 13 shows an ordinary valve gear, the data for it being as follows:—considering one of the L. P. cylinders of the example.

Dimensions

Stroke of engine.	22″
Connecting-Rod Ratio, "a".	¼
Travel of Valve.	5″
Length of Eccentric Rod.	52″
Angular advance of ahead eccentric (outside admission valve)	135°

Weights

Item No.	*Description*	*Pounds*
1.	Valve and rigid attachments.	292
2.	Radius Links.	90
3.	Drag Links.	56
4.	Each eccentric rod and strap.	147
5.	Top half of rod.	67
6.	Eccentric Sheave.	65

Now, separate these weights into ahead and astern, reciprocating and revolving. Item 1 is all reciprocating and belongs entirely to the ahead gear. The radius links, item 2, are divided equally between ahead and astern. Of the drag links one end is at rest, the other reciprocating with the head gear. As to the eccentric rod and strap—there is one for each gear, ahead and astern. This being a connecting rod we concentrate its weight at the two ends, regarding the bottom half as concentrated at the eccentric centre and revolving. The sheaves are all revolving. The results are shown in the accompanying Table I.

Table 1. Valve Gear

Item	Total Weight	Ahead Gear		Astern Gear	
		Reciprocating	Revolving	Reciprocating	Revolving
Valve and rigid attachments	292	292			
Radius Links.	90	45		45	
Drag Links.	56	28		28	
Eccentric Rod and Strap	147	67	80	67	80
Eccentric Sheave.	65		65		65
Totals.		432	145	140	145
Virtual Primary Weights Reduction Factor $\frac{5}{220}$		96	33	32	33
Virtual Secondary Weights Factor $= \frac{5}{22} \times \frac{5}{52}$		2		1	
Crank ahead of Cylinder crank		135		225	

The only necessary change for the other valves will be in item 1. We then have all the information to enable us to add to the main gear polygons, lines covering the valve gear.

Estimating the Main Reciprocating Weights

These parts are the piston, piston rod, crosshead and the upper portion of the connecting rod, the last being found by assuming $g = 0.4$ (see p. 8). Secondary weights are found by multiplying by the connecting rod ratio $a = \frac{1}{4}$. We then tabulate as follows — (these weights are for the I.P. as being the heaviest reciprocating weights).

Table 2. Maximum Main Reciprocating Weights

Item	*Primary Weight*	*Secondary Weight (Reduction Factor of ¼*
(1) I P. Piston	615	—
(2) I P. Piston Rod	200	—
(3) Crosshead	300	—
(4) Connecting Rod (Upper Portion)	380	—
Totals	1495	374

The total of (2) (3) and (4), which do not change, remains 880.

Revolving Main Weights

These are the lower portion of connecting rod, the crank and the crank cheeks. The second and third are to be reduced to vertical weights which have their centre of gravity at the crank pin centre. This is done by multiplying them by the factor,

$$\frac{\text{Radius of centre of gravity of crank cheeks}}{\text{Radius of centre of gravity of crank pin}}$$

Table 3. Main Revolving Weights

Item	*Weight*
Crank Pin	200
Crank Cheeks (virtual)	350
Lower portion Connecting Rod	570
	1120

Procedure for Reciprocating Balance

The characteristic features of the four-crank balanced engine are:—

(1) Maximum reciprocating weights on centre cranks; these weights approximately being equal and from 1¼ to 1½ times the mass of the two outer weights which are also nearly equal.

(2) Centre cylinders from 1.5 to 2 + times the distance apart of the outer cylinders.

(3) Cranks of forward pair at about 90° with cranks of after pair.

(4) Uneven crank angles.

The above values may be considerably altered, but only by adding considerable weight to the pistons and involving a large secondary couple.

From the diagrams of Taylor or Inglis we now find that arrangement of cranks which, with our given cylinder spacing, gives the least unbalanced secondary moment. This arrangement is as follows:—

$$\text{given } \left.\begin{aligned} l_B &= 0.242 \\ l_C &= 0.716 \\ l_D &= 1.000 \end{aligned}\right\} \quad \begin{array}{c}\text{Taking Reference Plane} \\ \text{through cylinder } A\end{array}$$

$$\text{Then } \left.\begin{aligned} \theta_A &= 65^\circ\ 50' \\ \theta_B &= 267^\circ\ 50' \\ \theta_C &= 160^\circ\ 20' \end{aligned}\right\} \quad \begin{array}{c}\text{Angles measured} \\ \text{forward from Crank D.}\end{array}$$

$$\text{and } \left.\begin{aligned} \frac{W_A}{W_D} &= 1.053 \\ \frac{W_B}{W_D} &= 1.46 \\ \frac{W_C}{W_D} &= 1.463 \end{aligned}\right\} \quad \begin{aligned} &\text{giving in terms of } C = 1495 \\ &W_A = 1077 \\ &W_B = 1491 \\ &W_D = 1022 \end{aligned}$$

This enables us to draw trial polygons for primary forces and moments including the valve gear, and secondary forces and moments, neglecting the latter which, as Table 1 shows, are very small.

A simple method is to draw separate valve gear polygons, thus obtaining the resultants due to them alone, using only these resultants which will not greatly change due to what small crank angle manipulation is necessary, checking the resultants before drawing the final polygons.

The object in drawing the secondary moment polygon which cannot possibly be closed is to be able to note the changes of the resultant couples due to changing weights and angles. The endeavor should be to keep this resultant a minimum. (Since all force polygons are to close, resultant moments will be independent of the position of the reference plane, i.e., they will be couples. Hence we may choose any point for the plane, preferably on a cylinder centre line).

Having now closed the polygons we scale off the weights from the primary polygon and compute them by adding weight to the various pistons. Thus the required weights of the three pistons are, (from Table 2)

H. P.	1460 — 880	= 580 lbs.
L. P.$_1$	1130 — 880	= 250 lbs.
L. P.$_2$	1065 — 880	= 185 lbs.

and the crank angles are as given on the diagram. The relatively small changes required due to inclusion of valve gear should here be noted: W_A being changed by + 53 lbs.; W_B by — 31 lbs.; W_C remaining unchanged, and W_D being changed by + 43 lbs., making a total of + 65 lbs.

θ_A is changed by $4^\circ 10'$; θ_B changed by $2^\circ 50'$, and θ_C by $4^\circ 40'$.

Revolving Balance

Revolving polygons are not shown, but there will now be no difficulty in obtaining revolving balance. Crank angles must not be disturbed, so balance is obtained by fitting counterweights to the foremost and aftermost crank cheeks. The farther apart these weights are placed the less they will, in general, have to be.

For a complete discussion of every phase of the problem of engine balancing the reader can do no better than to consult the Transaction of the Institution of Naval Architects of Great Britain and of the American Society of Naval Architects. All papers of any importance on the subject will be found reprinted in *Engineering*.

Hiawatha's Rodding

By E. C. Easy, C.E.

in "Engineer Clubman"

After Longfellow—A Trifle Footsore.

Skimped the huckleberry crop was,
All the other berries also.
Rasp-, and black-, and goose-, and whortle-,
Scant they were as tropic snowballs;
Not a square meal in a square mile;
Scarce as aluminium oysters,
Few almost as golden crowbars;
Not a deer in score leagues' distance—
Not a cat-fish, nor a dog-fish,
From the current could he cozen.
Not a catbird nor a titmouse,
From the forest could he ferret,
So that Hiawatha, hard pan,
Had got down to—good and plenty.
E'en for gulls' eggs was he hard up:
Sandbanks all suspended payment.
Naught of luck there seemed his portion.
Cold the summer, few the tourists,
Tourists to act guide to—shewing
Vacua to cast their bait in.
Empty pocket—Hiawatha's.
Up to him was now to hustle,
Railing the high cost of living.

Luck would have it then he chanced with
Engineers who shy of help were.

Hiawatha quick decided
That he'd give a moving-picture
Of an Indian plus some money.
He besought the chief of party:
"Give me of thy wad, O paleface,
Of thy pleasant plunks, O Big Chief;
Fain I woulds't toy eftsoons with 'em,
Much I like 'em for their crispness,
For their longness, also greenness,
For the picture-Indians on 'em;
For their scarceness, too, I love 'em—
Sparsely bank notes grow on bushes,
None too frequent in fat bunches."
Cinched the Indian, first thing offered.
So, behold you, Hiawatha,
New installed as rodding redman.
Careful heed he paid to, anxious,
All th' injunctions and advice notes
That the lev'ller put him over;
How to hold the rod straight upright
Parallel to 's major axis
When he stood erect—no cricks in
Shoulder—back, too, it all free from
Sneakish twists of wolf-rheumatics—
Verticality to rival.
Such the lesson, long, absorbing.
Taught he was, too, ne'er to slant it;
Nor to wave it unless signed to;
How to pick out stones and root-knobs,
Turning-points so they could serve for;
How to shape a bench-mark, ledge-like,
With his hand-axe on a green trunk;
Lots of cunning, saucy pointers
Hiawatha nailed whilst harking
To the lecture-leaking lev'ller.
"Snakes, I'll show him I'm no ninny,"
So thought Hiawatha, itchy
To get pay-day one day nearer.
"'Tis a cinch, the job's a melon,
Pumpkin pies are toad stools to it;
I'll not let the long stick wobble,
Or some figures might drop off it.
As a rock I'll hold it steady,
Rock that lightning could not phiz on."
Broke to harness, Hiawatha.

Through some pretty bumpy country
Ran this trial-line we speak of;
Thick lay desperate gulches 'thwart it,
So that levelling no snap was—

Short the foresight, sawed-off backsight—
Difficult to read the hundredths—
Hard to see tenths indicated—
Feet in red most to be guessed at—
Trying to a Job's own temper
Was Smith's chauffage of his level—
Smith who took some flying levels—
Two legs mostly stuck 'way down hill
With the third poked towards high heaven;
Plates like clam shells when half-opened—
Swear-words quite facile of utt'rance
For the gent who shoved the level—
Yea, *some* hot uns—on the level!
But the twain kept right on at it—
Our friend Smith and Hiawatha—
Gad! Rewarded soon they felt like,
For, stretched out before them, shadowed,
Now they viewed a plateau pleasing,
Where the boles reared tall and stately,
Stately, fronding high, and yielding
Park-like vistas every-which-way.
Straight, long shots were here aplenty,
Far as telescope screwed good for.
Joyful he, John Smith, at field-work,
Knew his profile easier plotted
And the nicks between the high humps
Not in-growing, so deep-seated.
Thus the hog-back's plane they ate up,
Every second booking similar.

In this life, though, to an end soon
Everything in time doth come to:
Which was why they next confronted
One vast valley, most abyssmal.
Sheer and tangled were the hill-sides—
Windfalls, underbrush, all riot,
Like some canyon-wild, horrific—
Dante paints in his Inferno.
Smith he gasped quite—nearly throttled—
At the gulchy nightmare's viewing.
Was it safe to trust a long shot
'Cross the chasm far down below 'em?
Trust his level's high horse-power,
Trust the lenses' rare perfection?
Still, the more he rubbered downward
Past his toe-stubbed pair of shoepacks,
At the bally kind of riot
Strata, boulders, all seemed up to—
Typical of age Huronian—
More thought he to risk the chances—
Yep, sure Mike, he'd take a chance.

Hiawatha, so, he ordered
Down the depths to dip the dips;
Upward, then, to scale the rampart
Fronting where he had his set-up;
There to annex some good object
On the distant bank forninst 'em,
Fit to serve as bench-mark stable—
Rods behind him was the last one.
And addressed he, Hiawatha:
"Choose a good spot, Hiawatha;
Choose a pink-peach mark, O Indian;
That done can we hike for campwards,
Sneak, bee-line, for pan and kettle.
Soon will sun be low declining,
To his couch of red boughs sinking."
Nothing much spoke Hiawatha—
Language-vendor was he none of.
Down he clambered featly, thinking,
"This game's skin-tight to my measure;
This act I'll do scientific."

'Long about two-pipes-full later,
Smith, half-sleepy by his level,
Caught a distant whoop-la, proving
Hiawatha'd wriggled through it,
Spanned the fretful gulch between 'em.
Sprang to arms, did Smith, the lev'ller!
Spied to see the winking bubbles!
Swung the telescope twice crosswise,
Thumbscrews wooed he, wheedling, till he
Had all just-so for th' exposure!
Carefully his reading took he
Once and twice and thrice, ere booking;
Checked some more to see 'twas entered
Fair in virgin black correctly.
Last, he signalled his companion,
Waved him homeward o'er the gully.
Quit with work for that day was he;
Done was Smith, save for reducing.
Thoughts of frying pans he nurtured,
Thoughts of flapjacks toothsome in 'em,
Of the kettle's strong brew thought he.

Next morn, after strenuous labor,
Jamming shins and barking elbows,
At much cost of verbose temper
Smith and party, viz.: his rodman,
Reached at length the coign of vantage
Whence Smith was to, if per usual,
Make his H. I. diagnosis.

Faring onward, Smith had questioned
Hiawatha of his bench-mark.
Had he copped it well and truly?
Was it root, or stone, or bathbrick,
Had he smeared it well with red chalk?
Would he ken it from a puffball?
All such queries were projected.
Fine disdain were they received with.
Lo, the Indian seemed some touchy.
Smith, the leveller, thought it funny,
Verbiage grows, though not on 'Jibways—
He decided not to worry.
Now they'd won the sought-for station,
He, however, closer questioned;
Questioned for his pulse beat quicker,
Seemed to sense some hard-boiled blunder;
Asked the Indian quick to pipe him
Where he'd held the rod *last evening.*
Then it was that Hiawatha
Lent a baleful optic to him
And related how—not finding
Either rock, or stone, or such like—
He'd kidnapped an obese turtle,
Pressing hard his rod upon it;
Held it, plumbed it, waved it, raised it,
(Note: The rod's meant, not the insect.)
Keen obedient to the signals;
Then when big-waved O.K. backward,
He had found some string about him
And had tethered tight the turtle
To his sheaf-knife, earth-embedded.
Up and down, all higgl'y-piggl'y,
Lay the area could be skirt-danced
By that slackly snubbed-up turtle,
So that boy, nor man, nor woman,
Germ, nor beast, nor bug, nor microbe,
Might they tell within a 'phone-pole's
What said turtle's elevation,
E'en if na sae keen on rambling.
Crushed to earth, poor Smith, the lev'ller;
Gruff and silent Hiawatha.
Crushed to earth, Smith's brand new hat was,
For he camped and jumped—yelled—on it—
Something cruel, most egregious.
Gruff and silent Hiawatha.

This then is the tale so simple,
Told by Kagh, old Kagh, the hedge-hog.
This the tale how Hiawatha
Got the sack from railroad survey,

Forewent being rodman redman;
Beat it to his lodge-fire, hungred,
Touching only just the high spots—
All his fond hopes fair turned turtle—
Much cursed he the cost of living;
Swore to ring up old Nokomis
When he'd get the line not busy—
("Musquosh: Six-O-Four: 's the number.")
In the turtle-soup, sir, was he—
Nary 'mock' at all about it—
Hiawatha. ("Line still busy!")

THE ENGINEERING SOCIETY AND THE ALUMNI ASSOCIATION*

By T. H. Hogg, B.A.Sc.

There is little excuse on my part for venturing to address the Engineering Society at this meeting. When your president, Mr. Ritchie, requested me a few days ago to give you a short talk on the general relationship existing between the undergraduate and the graduate bodies of the Faculty of Applied Science, I hesitated, for since my association with the society, some few years ago, I have felt that the meetings of the society should be addressed only by men who might have something of definite value to present to the members. In thinking over the matter it occurred to me that perhaps a short resume of the history of the society during the past few years might be of some service, together with a few words on the present status of the Engineering Alumni Association.

As you probably all know, the Engineering Society has existed since 1885, about eight years after the founding of the School of Practical Science. I believe that Dean Galbraith, then principal of the School of Practical Science, was responsible in no small measure for the success attending its early years, as he has to the present been responsible for its continued existence and widened sphere of influence. Messrs. Herbert Bowman and T. Kennard Thomson were the undergraduates who actively promoted the society at its inception. Mr. Thomson has, through the past twenty-five years, remained one of the Engineering Society's best friends and one of the School's truest graduates. No labor is too great for him when the interests of the Faculty are at stake. The Engineering Alumni Association has many times called on him for his time and attention, and he has never failed to respond heartily. This is true, however, of a majority of the graduates, and I sincerely hope that it will continue to remain so.

Professor H. E. T. Haultain was the first student presi-

*Delivered at a meeting of the Engineering Society, October, 16, 1912.

dent, for Dean Galbraith acted in that capacity for the first three years of the Society's existence. Since that time a long list of students has filled the president's chair, until in Mr. Ritchie you have your twenty-fifth president.

Many noteworthy events have taken place in the Society's history. The Engineering Society has always stood for the best interests of the students, the graduates and the Faculty itself. Perhaps no one is better fitted to give testimony to that than our Dean, and I am sure he will bear me out. I do not wish, however, to dwell on this history, as these remarks are preparatory only to what I desire to say.

It is necessary, however, before leaving its past history, to draw attention to one man who, perhaps, above all others, of the student members, has been responsible for the present strong position of the Engineering Society among University organizations. This man was Mr. K. A. Mackenzie, who was president in 1906-07. Mr. Mackenzie was president at what was one of the most critical times of the Society's history. The supply department, inaugurated a few years previously, had developed enormously, but was still being handled by a student secretary. The meetings were large and unwieldy, and it was difficult to obtain men to address these meetings on subjects of common interest. The graduates were rapidly increasing in number, and no attempt was being made to hold them together and keep their interest in the Faculty. The Transactions, issued annually, were becoming unwieldy, and were a heavy tax on the income of the Society. In fact, at that particular time the organization was in shape for trouble unless radical measures were taken to change the constitution. The changes that were made at that time, I believe, helped to place the Engineering Society in its present position, as one of the most powerful organizations in the University of Toronto, and as one of the most unique in the universities of Canada.

It was on Mr. Mackenzie's initiative that a new constitution was drafted, in which provision was made for sectional meetings, and for the appointment of a permanent secretary. With Mr. Mackenzie as the first permanent secretary, a new era dawned for the Society, and you gentlemen are reaping the results of that change of constitution in the magnificent supply department under your charge to-day. The next move was the changing of the Transactions of the Society into "Applied Science," a monthly publication, this again being due largely to Mr. Mackenzie. This move, together with the appointment of a paid secretary, has had a most far-reaching effect outside the undergraduate body. Its results are noticeable in the formation of the Engineering Alumni Association. Before that time no graduate organization existed. As a direct result of the changes above mentioned, and by the efforts of a few of the more enthusiastic graduates, the Engineering Alumni Association in Toronto was formed.

At the present time there exist Alumni Branches in Montreal, Timiskaming, Victoria, B.C., Pittsburg, New York, as well as in Toronto. This year it is hoped and expected that a few more may be founded in the West. The Toronto Branch of the Engineering Alumni Association has acted in the past as the central organization of the graduate body. While it is really only a branch, it has to a great extent molded the policy of the Alumni Association, and has freely called on the other branches of the Association for their support at critical times. As yet, there exists no permanent general Alumni Association, the Branch Associations now formed being really graduate bodies of the Engineering Society. Last year, with the idea of still more closely welding the undergraduate Engineering Society with the graduate Association, M. H. Irwin, your permanent secretary, was elected secretary of the Toronto branch of the Engineering Alumni. It is hoped in the future, as the organization develops, and an executive committee representing the whole graduate body is chosen, that your secretary will act as the secretary of the general committee. The Engineering Society was extremely fortunate, when, on losing Mr. Mackenzie's services a couple of years ago, it was successful in securing your present secretary. Mr. Irwin has done a great deal already for the furthering of the interests of both the undergraduate and the graduate, and in his present position is so located that he will be able to do a great deal more.

It is necessary to understand conditions some eight or ten years ago to properly appreciate the great amount of work which has been done towards organizing the graduate body, and I hope that these remarks will aid to a proper understanding of what has been done. The Alumni Association is to-day in a stronger position than it ever was before. The results are beginning to show in the scholarship fund, which is being furnished by the graduates for the founding of research scholarship in the Faculty. This year, as you know, at least one, and perhaps two appointments* will be made, and it is expected that each year hereafter two Fellows will carry on research work through funds furnished by the Alumni Association.

In closing these remarks it would not be fair to omit reference to the co-operation of the Dean and members of the Faculty in advancing the interest of the Engineering Society. At all times during its past history, the Dean has been close to the executive committees, guiding them with his advice and strengthening their hands by aiding in whatever changes in the constitution had become necessary due to the new conditions. The Dean has been responsible in no small measure for the unique position the Engineering Society holds in this Faculty.

I understand that there is some thought this year on the part of the executive committee to alter the custom relative to

*Tnese appointments, mentioned in September "Applied Science," have since received the sanction of the University Scholarship Committee, and the men are at work.—Ed.

the annual dinner. The subject is one which merits discussion. The annual dinner is a function which has become a part of the life of the School, and I am sure that if it were dropped it would be the occasion of much regret on the part of the graduates. The dinner serves many purposes. Not the least among them is the fact that it is the only official occasion on which the Faculty and the Engineering Society come before the public. On the other hand, I understand that during the past few years the deficit in the dinner proceeds has become increasingly large and increasingly hard for the Engineering Society funds to handle. It may be that the time has come for a change to be made, but, personally, I sincerely hope that the executive committee this year can see their way clear towards preserving this annual function.

As a last remark, I would like to remind those members of the Engineering Society who are not in an official capacity, that in the year now beginning they co-operate in every way possible to help the present executive in carrying on the work of the society. As one who has been a member of the executive committee, I appreciate the amount of work which devolves on them. If you, as members of the Society, will only do your share, it is certain that the dinner will be preserved for this year, and that a new impetus will be given it which will do much towards securing its continued life.

DR. DUSHMAN

At the opening of the present session, Dr. Saul Dushman resigned from the position of lecturer in electro-chemistry to enter the employ of the General Electric Company at Schenectady, N.Y. His withdrawal is a matter of regret to both faculty and students, and the University has lost the services of an able investigator. Dr. Dushman, who is of Russian parentage, came to this country as a boy, and was educated at Harbord Collegiate Institute. He then entered the University, and, after a brilliant course, graduated in the Honor Department of Physics and Chemistry in 1904. He was immediately engaged as fellow for the recently created department of Electro-chemistry, and became in succession demonstrator and lecturer in this subject. Early in 1912 Mr. Dushman presented a thesis entitl d, "The Behaviour of Copper Anodes in Chloride Solutions," and received from the University of Toronto the degree of Doctor of Philosophy.

Dr. Dushman's enthusiasm has been an inspiration to his students, and he has been able to imbue them largely with his own ideals in scientific work. Gifted with an unusually alert mind, he has been able to keep abreast with the progress in other branches of science besides chemistry, and his broad reading has made him an interesting companion as well as an excellent teacher.

Dr. Dushman, while here, took an active interest in some of

the student societies and has been a frequent contributor to APPLIED SCIENCE as one of the associate editors.

He has entered the research laboratory of the General Electric Co. after spending some months during the summer in becoming familiar with the work. This laboratory maintained on an elaborate scale, and devoted to problems arising in the manufacture of the company's products, or to developing ideas into commercial possibilities, is famous for the high standard of the work which is carried on and for the success which has been achieved. Dr. Dushman will find ample scope for his abilities in his new position and his advancement may be confidently expected.

As an advisory on the APPLIED SCIENCE board, as an efficient and persevering instructor and as a close adherent to the ideals of University life and scientific advancement, Dr. Dushman will long be missed.

It will be remembered by readers of APPLIED SCIENCE that Dr. Dushman experienced the distressful misfortune of losing his wife early last summer. In deeply regretting his departure from University circles, it is felt that this sad occurrence may be not a little responsible for his disengaging from academic work and devoting his energies to the deep and thorough concentration of mind which research necessitates.

ENGINEERING ALUMNI ASSOCIATION FUNCTIONS

The Montreal Branch of the Engineering Alumni Association is holding its fall dinner on November 1st. It is expected that all the School men in that city and district will be in attendance. It is hoped that any other graduates who happen to be in the vicinity at that date will also notify the secretary, Mr. H. W. Fairlie, 1577 Mance St., Montreal.

The Temiskaming Branch of the Engineering Alumni Association is holding its annual dinner in Haileybury on Friday evening, November 8th. In the neighborhood of sixty graduates and undergraduates of the Faculty of Applied Science reside in the northern district, and it is expected that the majority of them will be at the dinner. The secretary, Mr. H. W. Sutcliffe, New Liskeard, and his Council, are making preparations for the most successful dinner ever held in Northern Ontario.

P. H. Stock, '09, is on railway construction work for the Niagara, St. Catharines & Toronto Railway. His address is St. Catharines, Ont.

F. W. Clark, '11, is in the employ of the International Waterways Commission, and is stationed at Niagara Falls, N.Y.

E. A. Kelly, '11, is located in Winnipeg and is engaged on construction work for the Canadian Pacific Railway.

A. I. Davis, '09, is in Ottawa, Ont., as salesman for the Canada Foundry Co., Ottawa Branch.

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EDITORIAL

THE HIGHER STANDARD OF ENTRANCE

The Department of Education enacted a vital measure when it stipulated senior matriculation as the required standing for our prospective first year men. The announcement was made several years ago and the clause came into effect at the opening of the present term. It is the controversial opinion that the School has made an important advancement thereby. It will admit only men who have the training which a year or more in the higher form of the High Schools gives. They will come with better established purposes—bent upon securing all that their investment in an engineering education is capable of giving.

For a number of years the fact has been noticeable that the Engineering course is occasionally chosen by men for other than their firm conviction that engineering is a profession they intend to follow. It is frequently a matter of association rather than one

of definite purpose. This is detrimental to the welfare of the School as its output suffers a lowering of standard thereby. The new regulation will tend to bring a class with a better conception of the field before them. The curriculum will be put to a severer test and will be condensed and revised accordingly; several subjects now requiring time and lecture space in the first year time-table being eliminated, or replaced by others now drawing upon the time allotted to the second year, and so on. The entire engineering time-table will require altering, and in the desired direction.

The chief effect this year is in the reduced attendance. The first year is barely half its usual size. At the present writing (Oct. 24) the attendance by years is as follows: first year, 143; second, 205; third, 173; and fourth, 121; total, 642.

Not of least importance is the effect produced upon the sale of supplies in the Society's supply department. The decrease of 130 in the first year causes a proportional decrease in sales. Owing to the effect of the new requirement being much greater than anticipated in any quarter, the result may be summed up by the statement that, except in the supply department shelves and cases, no crowding obtains this year in the old Engineering Building.

THE NEW STRUCTURAL ENGINEERING OPTION

With the object of affording students in civil engineering an opportunity of acquiring special training in the design of structures, there has been inaugurated, in the Faculty, a Structural Engineering Option in the Fourth Year. It was recognized that a civil engineer in varied employment finds a knowledge of structures required of him perhaps more frequently than in any other department of engineering. So extensively do structures of one kind or another—bridges, buildings, foundations, retaining walls, dams, towers, tanks, flumes pipe lines and analogous constructions—enter into the carrying out of engineering projects, that a thorough acquaintance with the principles of structural design is practically indispensable to the civil engineer. The new option will particularly appeal to those who desire to fit themselves for designing or constructing engineers, or who contemplate entering the contracting field later on

The curriculum differs from that followed by other civil engineering students only in the fourth year. Certain subjects are also obligatory on all students in civil engineering in the final year, and of these some are of particular interest to those following the Structural Engineering Option. The obligatory subjects are Foundations, Electricity, Thermodynamics, Geology, Contracts and Specifications, and the writing of a Thesis on a subject selected by the student and approved by the Council. The course on Foundations consists of some twenty-four lectures on the theory and methods of construction of abutments, piers, footings, retaining walls and dams, with some practical problems of design worked out in the draughting rooms. Contracts and specifications, of

particular interest to the constructing engineer, are discussed in twelve lectures.

The elective subjects, now made available to those choosing the Structural Engineering Option are as follows:

Theory of Structures. A lecture course of about 48 lectures on so-called higher structures, such as swing bridges, arches, and suspension bridges. This is accompanied by the working out of several problems of design in the draughting rooms.

Strength and Elasticity of Materials. A laboratory course in the elastic and physical properties of the materials of construction, occupying, in all, some 144 hours.

Iron and Steel. In this course of about 24 lectures are discussed the relations between the composition of irons and steels and their physical properties. Some corroborative work is done in the laboratory.

Reinforced Concrete. A lecture course of some 24 lectures accompanied by the application of the principles learned to the design of reinforced-concrete floor panels, columns and girder bridges in the draughting rooms. This course covers the analysis of the monolithic arch by the theory of elasticity.

Structural Design of Buildings. A lecture course of 24 lectures accompanied by draughting room exercises in the design of building structures of timber, steel and reinforced concrete.

Mill Building Design. A course of some 24 lectures accompanied by work in the design of mill buildings, or portions of them, in the draughting rooms, The selection of type and the choice of the proper materials of construction to use are given special attention.

While the new course began with the present session, considerable interest has already been evinced in it, some 24 men having elected to take the option offered.

RESEARCH SCHOLARSHIPS

The Engineering Alumni Research Scholarships are both under way. The Faculty Committee approved of the awards and the men are at work. The Association is fortunate in having the co-operation of the staff of the Faculty of Applied Science in its scholarship movement. Their appreciation of the goodly aim and an assurance of their confidence has been evidenced by the great interest they have taken in the commencement of actual work. Their willingness to assist is most encouraging. Professor Rosebrugh has allotted desk and study room to Mr. Dobson in his own private office. Mr. Shaw has likewise been favored with office room in the Chemistry and Mining Building. Library facilities are open to each. Dr. Ellis, Professor Bain and Dr. Boswell, on Mr. Shaw's behalf, and Professors Rosebrugh and Price, upon that of Mr. Dobson, are giving all possible assistance. In short, the Fellows are not lacking in any detail from accommodation and opportunity at the hand of the staff of Applied Science.

THE ANNUAL DINNER

When the date of the twenty-fourth annual dinner came up for discussion at a recent meeting of the Engineering Society many opinions were expressed. Owing to the heavy drains the dinner has made upon the Society's resources during the past years, it was felt that such another should not be experienced again this year, and a decisive stand has been taken with regard to the renowned annual event. The monstrous dinner deficits of past years are without doubt the results of one Dinner Committee determining to outshine its predecessor in the magnitude and grandeur of its aim. If this is continued the dinner's good name among the social events in the University is going to be lowered. No other function, except perhaps the Engineering dance, has paralleled it in the past. It has been of great value to the Faculty and to the University, but there is such a thing as needlessly overstepping the mark in attempting to enhance its measure of success.

The School dinner is primarily for the School man, student and graduate, and the success of the affair will in future entirely depend upon his own inclination. To the undergraduate it is a yearly opportunity to spend a congenial evening in association with members of the Faculty in social frame of mind with academic manners and methods discarded, and of graduates who attend for the sake of old times, old themes, old jokes, and old faces, more than anything else. This means more to the student than he is capable of realizing at the time of the event. Always while a student, he should look forward to his graduation, and he should endeavor to gain the acquaintance and the interest of graduates who are years his seniors in Engineering—else when he graduates he finds himself a stranger entering the portals of the profession.

The stand which the Dinner Committee is taking with reference to making the affair a financial success should be endorsed by every student as it is to his interest more than to that of anyone else that the funds of the Society be not drawn upon on such occasion, but that they be conserved for more appropriate and beneficial use.

It is quite probable that the annual dinner will be held in December this year, to avoid a crowding of social events into the Easter term. The exact date has not been definitely decided.

BOOK REVIEW

The Theory of Machines, by Professor Robert W. Angus, University of Toronto. The University of Toronto Engineering Society, publishers. Cloth, 6 x 9 ins., 232 pages, 147 illustrations; $3.00.

As the title of this book suggests, it deals with the general theory underlying the construction of machines, and also with the application of the theory to the construction of actual machines.

In general in machine construction two distinct problems face the designer, the one dealing with the motions in the machine, the

effects of altering the proportions of various parts, such as crank and connecting rod in an engine, the effect of accelerations in the parts, and all similar problems. The other problem dealing with the proportioning of the parts is the science of machine design, the forces acting in the various parts being known and the parts being made of sufficient size to withstand these forces.

As Professor Angus has pointed out in the preface and is borne out by the book itself, problems of the first kind are those dealt with. In the first chapter the nature of the machine is carefully examined, the characteristics which it must possess, the relations of different forms of the same general construction and the connection between such machines as the steam engine, the oscillating engine, the Whitworth quick-return motion and other mechanisms.

The second and third chapters deal with the very important questions of motion and velocity in machines. The methods of finding the velocities of different parts of machines and of plotting these velocities are discussed in some detail, and the application is made to the determination of piston velocities and the rates of discharge from one, two and three throw-pumps.

In chapter four is discussed a very simple and useful method for determining velocities in the most complex machines by an easy practical construction, which is here published in detail for the first time. The method is illustrated by finding the velocity of the valve for a given setting of a Stephenson link and also by other problems.

Chapters five, six, and seven deal with toothed gearing. A comparison is first briefly made with other forms of gearing and then the proper form of the tooth outline is fully discussed and the two important forms, the involute and cycloidal, are investigated together with a comparison of their merits. The proportions of the teeth are also examined from the standpoint of motion, the strength not being considered.

Bevel gears are next being taken up in chapter six, the first case being where the two shafts intersect, giving the ordinary form of bevel gearing. A very common and difficult case is next examined, i.e., where the shafts do not intersect such as in the case of the crank and cam shafts of many gas engines. This gives rise to two forms of gearing depending on the desire of the designer, the first form being where large amounts of power are transmitted and hence where line contact is required between the teeth, while the second case deals with the worm and wheel in which there is a point of contact. The former problem, while complicated in theory, has been reduced to a most simple graphical construction for finding the dimensions of the wheels.

This is followed by the chapter on the trains of gearing in which the application of the gears to various machines is taken up. Such a machine as the screw-cutting lathe is taken as an example and the gearing is calculated. The epicyclic train for very high velocity ratios is also examined and illustrated in such a case as the Weston triplex block. Numerical examples and designs have been given here.

Chapter eight deals with cams and their construction and the method of laying them out.

In chapters nine and ten the effect of forces in machines is examined, the force at the crank required to crush the stone in a stone crusher, the same problem for a shear actuated by a cam, the turning moment on an engine due to the steam pressure, etc. In the latter problem the indicator diagram is taken and from it the turning moment is computed and plotted, and the relative merits of tandem and cross-compound engines, etc., form this point of view, are discussed.

The efficiency of machines is treated in chapter eleven and application made to several important machines, among which is a governor and a steam engine.

The next chapter treats of governors and examines the principles of construction and the determination of the weight of governor balls, etc., to fulfil given conditions. A method is here introduced which should be of great help to the designer, and a problem is solved in the design of a fly-ball governor to satisfy given conditions of speed, powerfulness and sensitiveness. The shaft governor is also studied and the general conditions to be fulfilled fully discussed as are also other forms of spring governors.

Chapters thirteen and fourteen deal with speed fluctuation in various machines and the methods adopted for controlling them. The method of computing the fluctuation for any machine is fully discussed and applied to the case of an engine where a numerical example of an actual case is worked out in detail. The same thing has been done for a gas engine.

The determination of the weight of the fly-wheels is made by a new method which it is believed is very useful and also numerical examples have been worked.

The last chapter treats of the accelerations in various parts of machines and the effect of the accelerating forces on the stresses in the parts and the pressures at the bearings as well as their effect on the turning moment. A numerical problem has been solved to illustrate the method.

The entire book attempts to deal with the machine theory from a general point of view, graphical methods have been used almost entirely, as the drafting board is always at hand for the engineer, and whatever theory has been introduced has been used rather as a means to an end, the graphical constructions usually being simple enough to be used by anyone not understanding the theory.

The book is the largest and most important of all the Engineering Society's publications.

M. B. Hastings, '10, until recently with the Toronto Hydro-Electric system, has accepted a position with A. H. Winter Joyner, Limited, Toronto, as sales engineer.

P. T. Kirwan, '10, is engaged as chemist at Capelton, Que., with the Nichols Chemical Co.